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MAIN CANOPY OF ISLAMIC COMPLEX, PUTRAJAYA, MALAYSIA – A TESTIMONY TO EXCELLENT PERFORMANCE OF PTFE MEMBRANE UNDER TROPICAL CLIMATE

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Summary. *This paper describes a landmark membrane structure where the surface appearance has been able to be maintained after years in service. The membrane structure is the main canopy structure located at the courtyard of Islamic Complex, Putrajaya, Malaysia. It is made using PTFE membrane which is known for its excellent durability. The construction process of the main canopy together with the mini canopy which consists of a group of four funnel-shape membrane structure made using PVDF membrane will be presented in this paper. The paper will also touch on the performance of PTFE membrane in humid tropical weather condition like Malaysia.*

1 INTRODUCTION

Membrane is known to possess high tensile strength(100 kN/m to 120 kN/m). Together with its lightweightness(0.5 to 2.0 kg/m^2), it can be used in structure spanning large column free space. Membrane should also be durable in order that the surface appearance right after completion of construction is maintained during its life span. This maintenance of surface appearance is especially important for membrane structure which serves as landmark for a public space. PTFE membrane is known for its excellent durability. Membrane materials with different surface coating perform differently under different weather conditions. Malaysia which is located in tropical zone at 2°N of equator has hot and humid climate. Sunshine radiation is about 6h/day on overage. The climate is affected by two monsoons seasons. Such harsh weather condition in Malaysia is expected to cause much significant changes in appearance and functional value of exposed surface of membrane materials. The

excellent performance of PTFE coated membrane was reported in an outdoor exposure test under tropical environment in Malaysia[1]. The best testimony of performance of PTFE coated membrane structure is to examine the record of actual constructed structure. In this sense, one best example can be found. Sports Science and Athletics Pavilion at University of La Verne, La Verne, California, USA, world first permanent tensioned membrane roof using PTFE membrane built in 1972 is still in operation after almost about 50 years[2]. In this paper, the excellent durability performance of PTFE coated membrane under tropical weather condition is reported by using the example of the main canopy of Islamic Complex in Putrajaya, Malaysia.

Putrajaya is a city and federal territory(since 2001) of Malaysia located about 25 km south of Kuala Lumpur, the capital of Malaysia. It serves as the administrative center of Malaysia. The prime minister office moved to Putrajaya in 1999. Islamic Complex Putrajaya is located in Precinct 3 of Putrajaya(Figure 1). The owner of the complex is TH Sdn Bhd while the architect was RSP Architect Sdn Bhd. It was developed based on beautiful urban architecture combining the harmony between traditional Islamic architecture and modern design. The Islamic Complex Putrajaya was completed in August 2016. The main canopy is located between two blocks of buildings within the Islamic Complex.

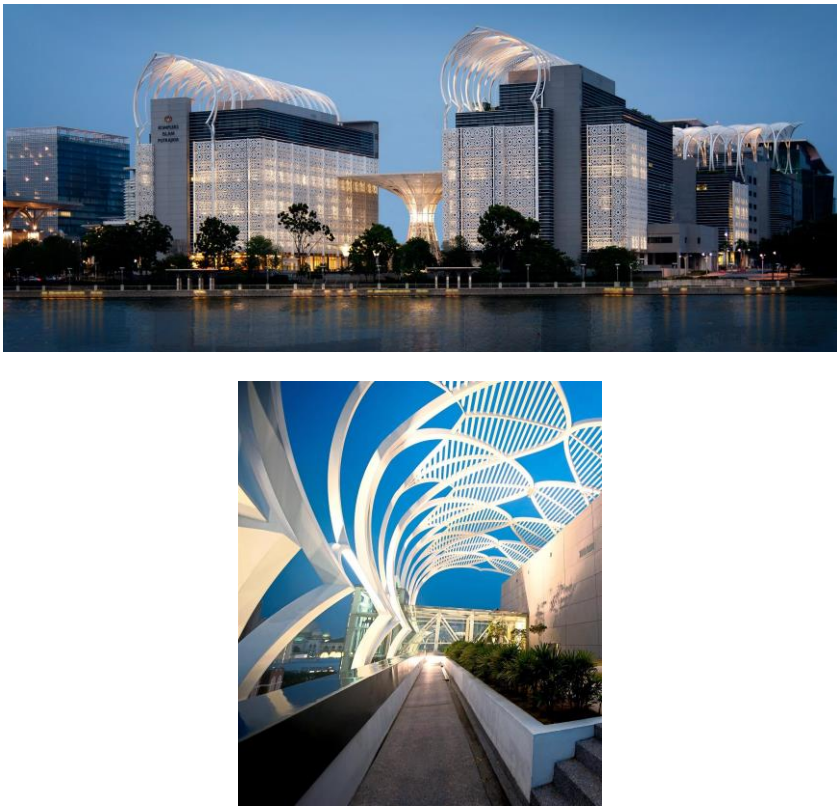


Figure 1: Islamic Complex Putrajaya (https://www.ppj.gov.my/page/kompleks-islam-putrajaya?slug=pelancongan-islam)

This paper describes the construction process of the main canopy. Challenges faced and solution adopted is also highlighted.

2 STRUCTURAL SYSTEM OF MAIN CANOPY AND MINI CANOPY

The overall shape of the main canopy structure resembles a funnel supported by a single layer space frame(Figure 2). It is located between two building blocks of Islamic Complex. It is made using PTFE membrane which is known for its excellent durability.

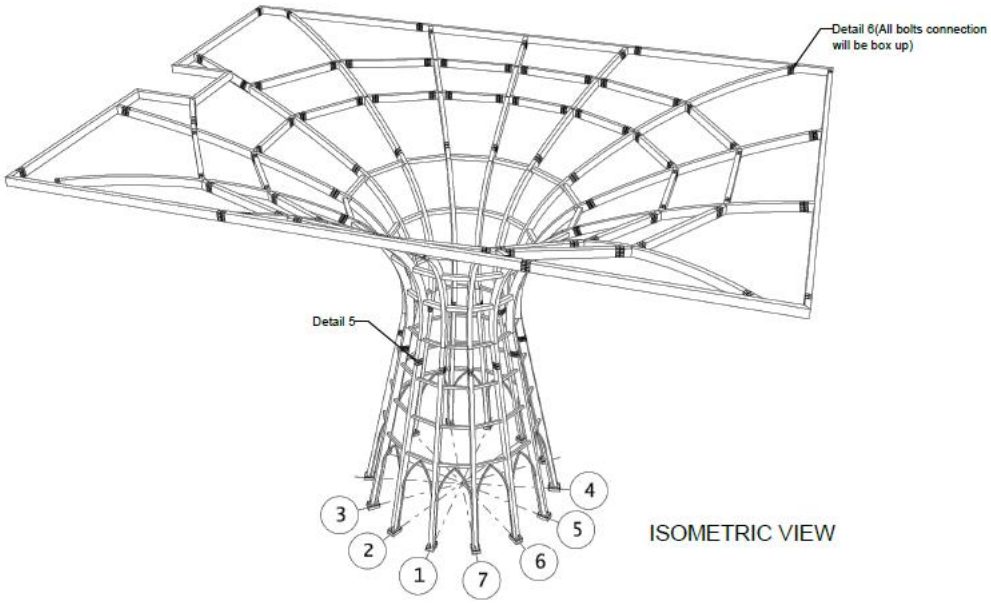


Figure 2: The supporting structure of PTFE membrane : Funnel shape single layer frame

The plan size of this membrane structure is approximately 27 m × 38 m while the height is approximately 26 m(Figure 3). Verseidag 18089 PTFE membrane was used to form a funnel-like surface within the single-layer space frame(Figure 3). The choice of the membrane material was made by the client due to excellent track record of PTFE membrane in terms of non-combustibility as per ASTM 136, self-cleansing property of the coating material Teflon and excellent service life of PTFE coated fiber glass fabric which is in excess of 35 years. Together with the main canopy, there is a mini canopy which consists of a group of four funnel-shape membrane structure made using PVDF membrane each measuring 8.4 m × 8.4 m × 6.75 m (height)(Figure 4). The PTFE membrane was fixed to the top square ring and the bottom circular ring of the supporting single layer space frame(Figure 5). Details of connection to top and bottom rings are shown in Figure 6 and 7, respectively. The M12 threaded rod used for tensioning of the PTFE membrane is shown in Figure 7. Both PTFE and PVDF membrane panels were fabricated in fabrication plant according to the cutting pattern as shown in Figure 8.

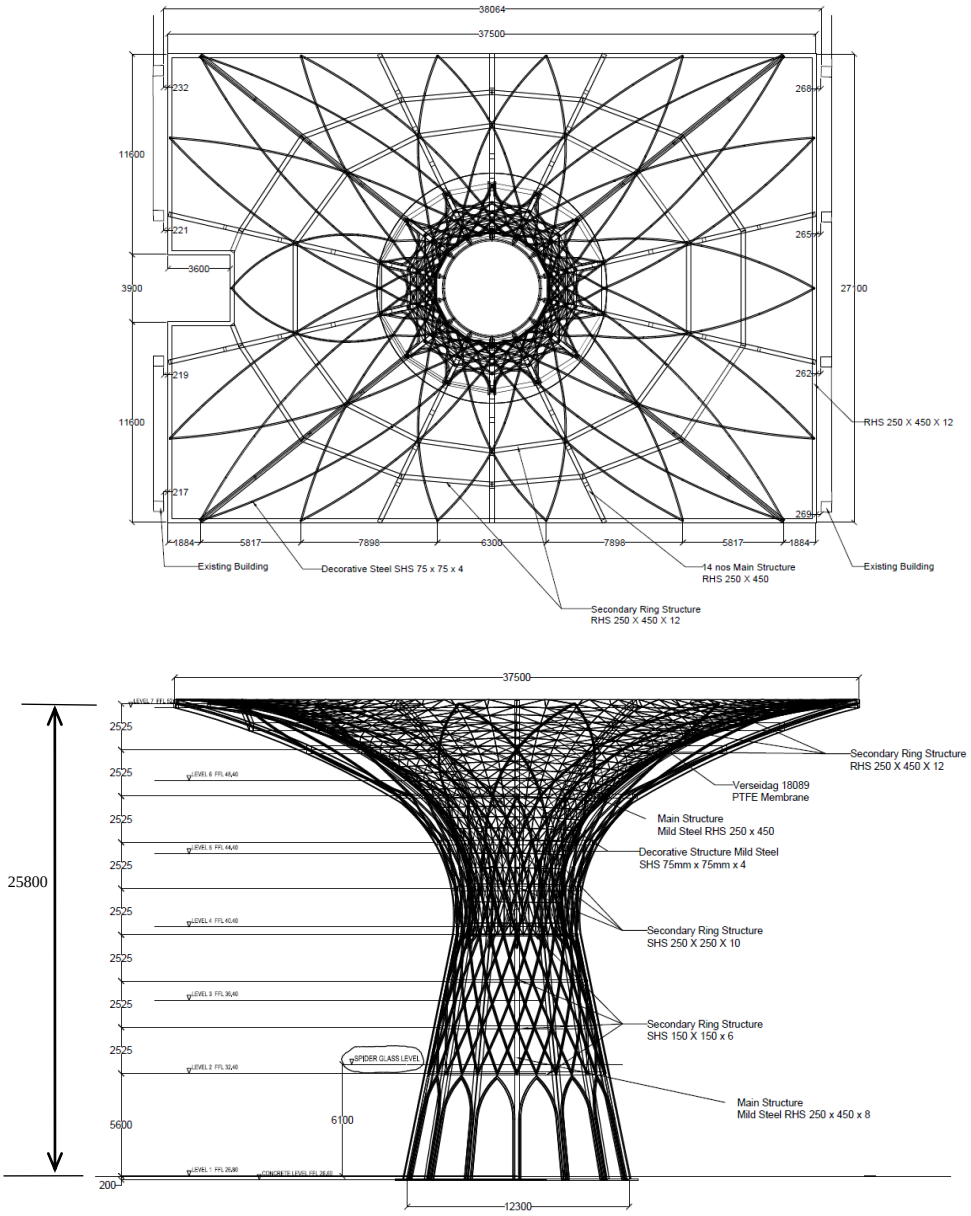


Figure 3: Dimension of the canopy - Plan and Elevation

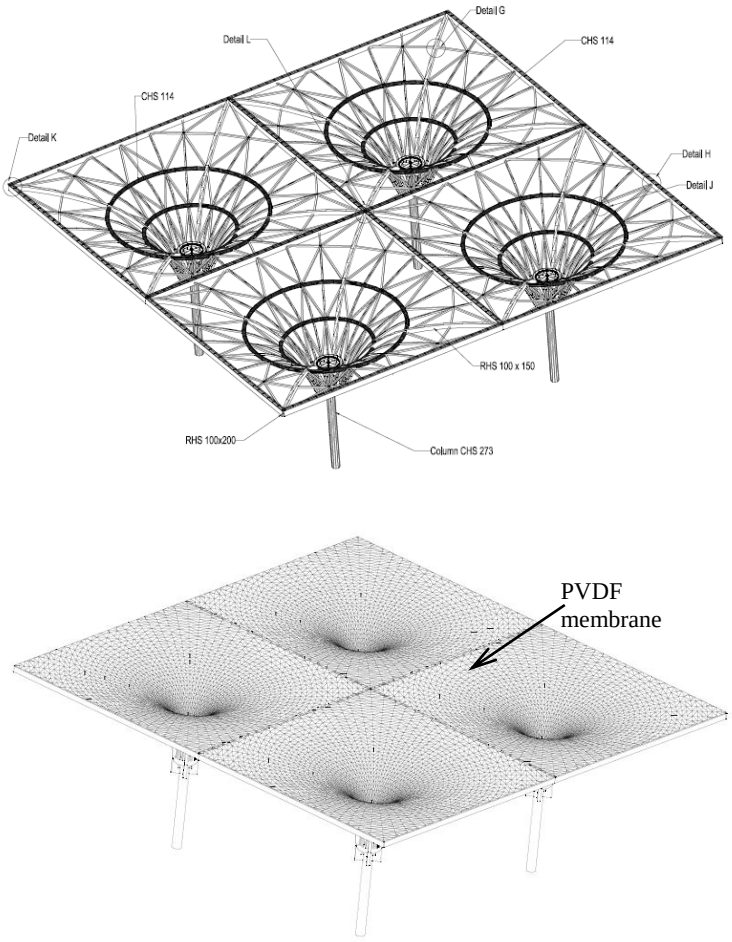


Figure 4: Dimension of the mini canopy – Supporting frame structure and membrane surface

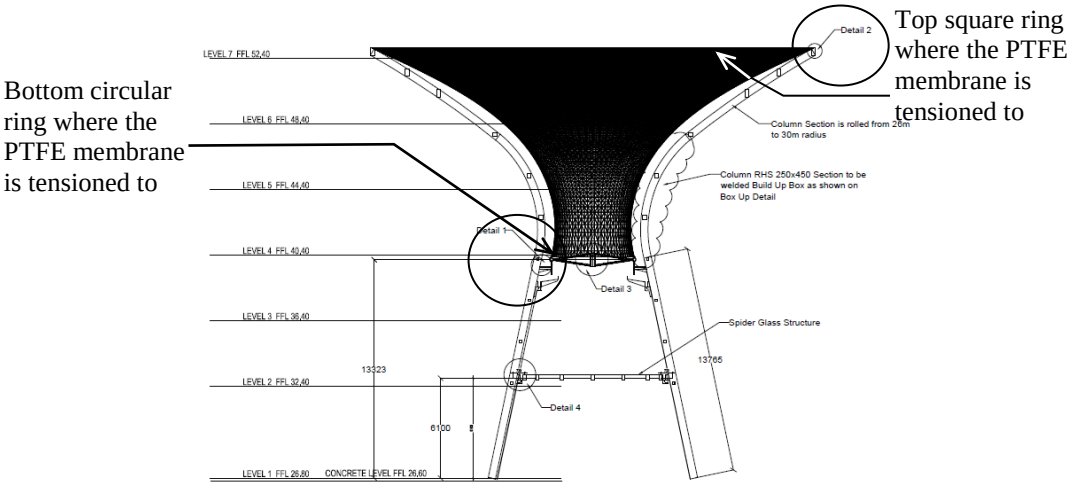


Figure 5: Top and bottom rings where PTFE membrane are fixed

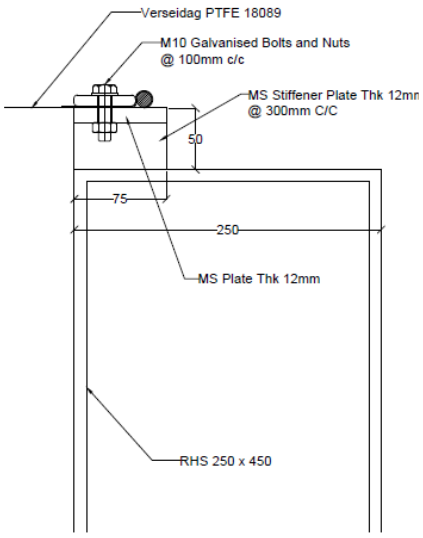


Figure 6: Details of top square ring where the PTFE membrane is fixed

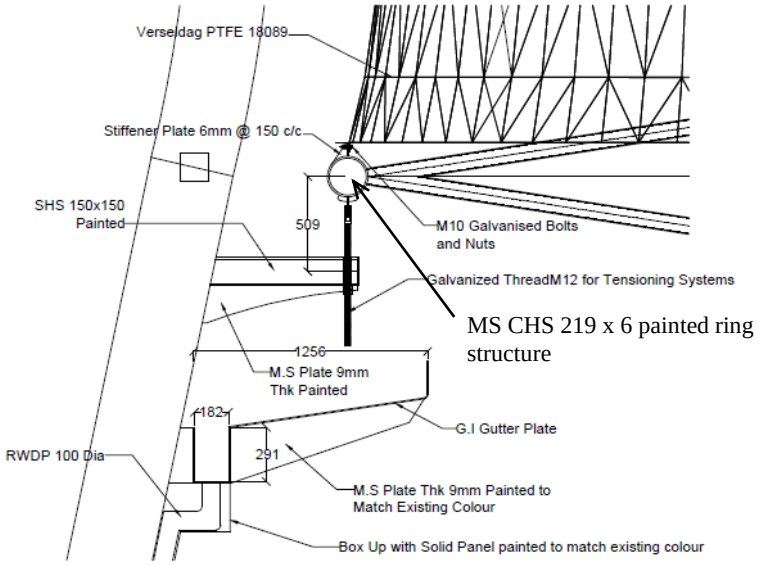
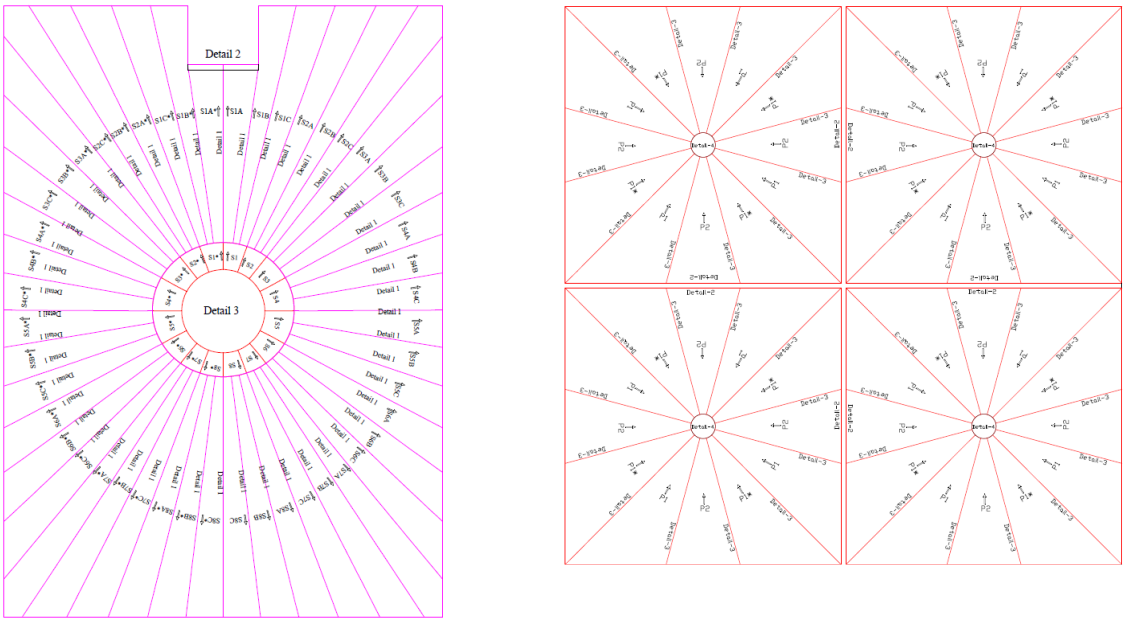


Figure 7: Details of bottom circular ring where the PTFE membrane is fixed



(a) (b)

Figure 8: Patterning layout of : (a) PTFE membrane ; (b) PVDF membrane

3 ANALYSIS OF THE MAIN CANOPY

Load cases of prestress+DL, LL(0.25kPa), WL(0.7kPa)(in (x,y)=-1,0, (x,y)=(1,0) and (x,y)=(-1,1) directions, where x,y are coordinate axis in horizontal directions) were considered. The envelopes of all cases for warp stress, fill stress and displacement are shown in Figure 9, 10 and 11, respectively.

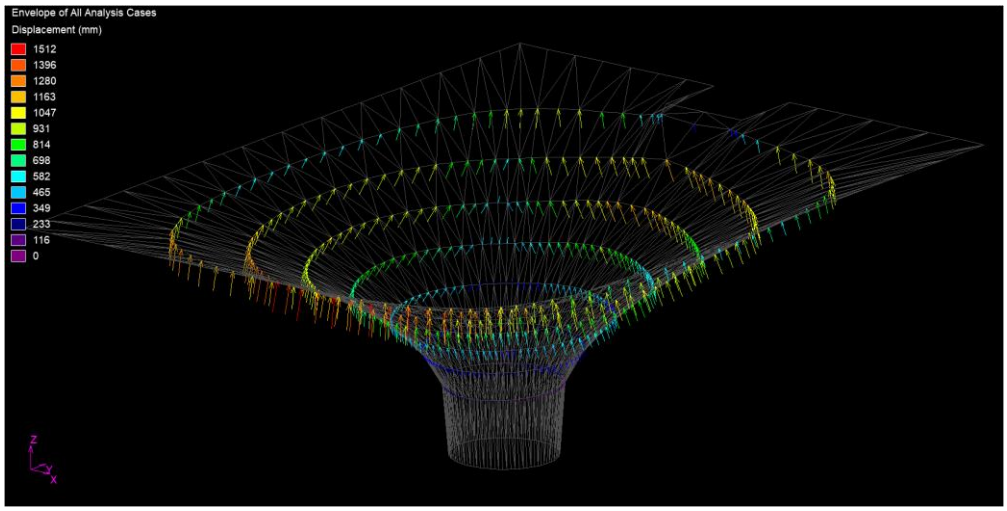


Figure 9: Displacement envelope

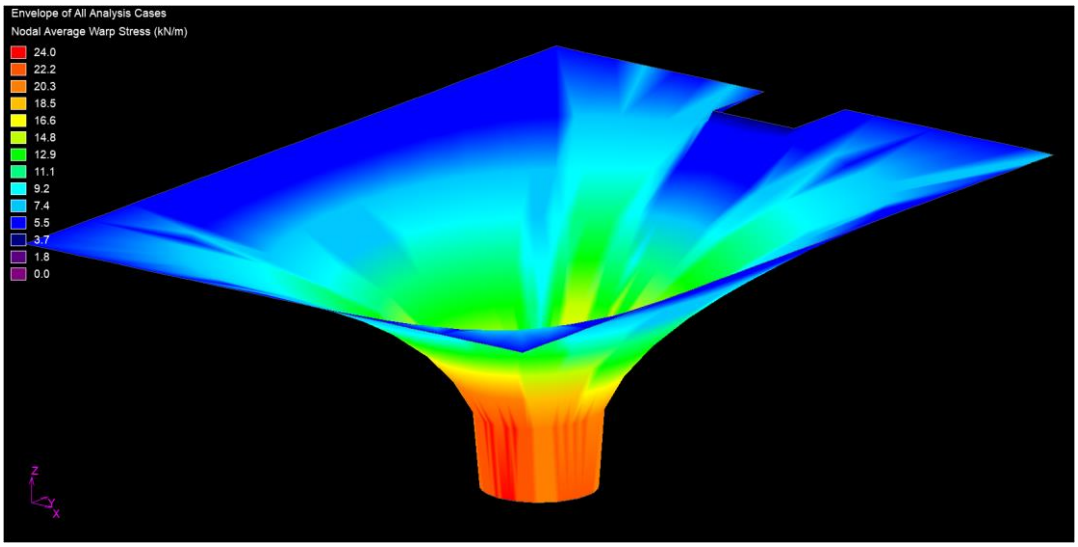


Figure 10: Warp stress envelope

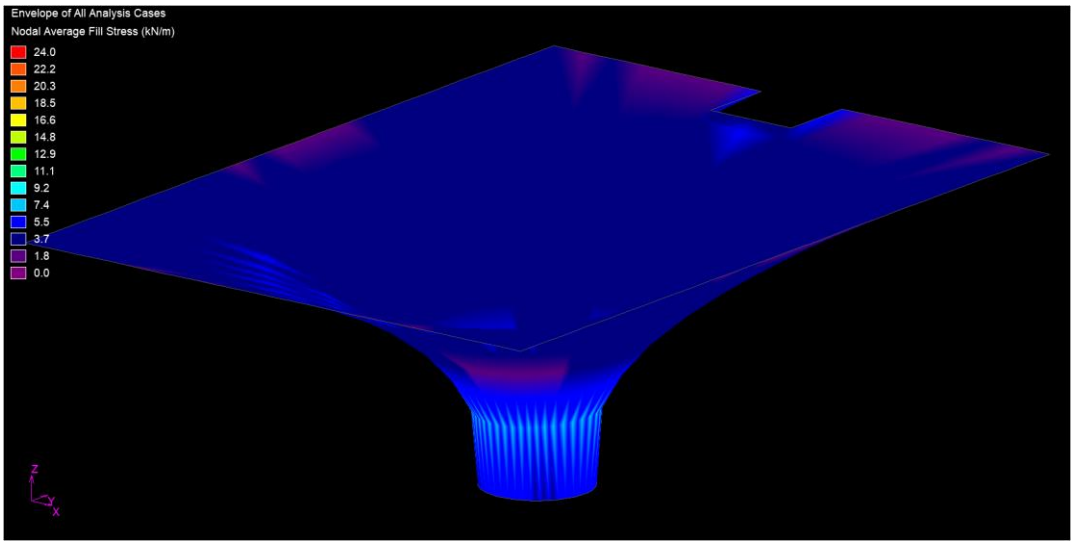


Figure 11: Fill stress envelope

The maximum warp stress was observed to occur close to the bottom portion of the PTFE membrane surface. The maximum displacement was governed by wind load case.

4 CONSTRUCTION OF THE MAIN CANOPY

The project duration was one year. In this section, only the construction of the main canopy is described. The process of construction of the main canopy started from erection of the supporting single layer frame which was then followed by the fixing of the PTFE. Figure 12 to 15 show the sequence of construction.

Figure 12: Construction of supporting single layer space frame

Figure 13: Completion of the supporting single layer space frame

Figure 14: Installation of the PTFE membrane

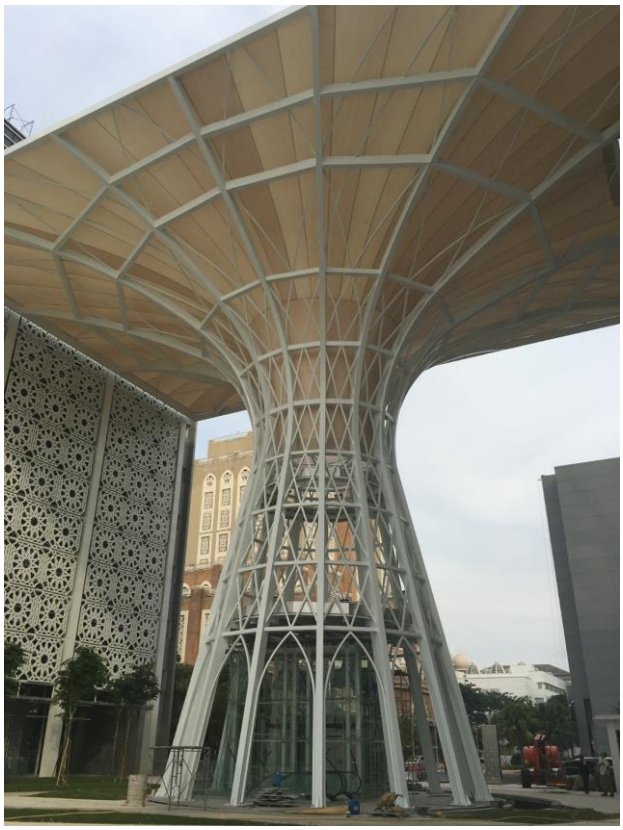


Figure 15: Completion of the installation of the PTFE membrane

One main challenge was faced during the installation of the PTFE membrane with glass fiber yarns. As it was fabricated in one single piece with no side jointing, extra care was needed during lifting up and spreading of the membrane.

5 CONCLUSION

The planning, design and construction of the main canopy of Islamic Complex Putrajaya in Malaysia has been described. This main canopy made using PTFE membrane has become an iconic landmark in Putrajaya since its completion in 2016. Figure 16 shows the appearance of the main canopy nowadays. The excellent surface condition is a testimony of the superiority of PTFE membrane in terms of overall stability when subjected to tropical weather condition.

(a)

Figure 16: The main canopy of Islamic Complex Putrajaya

(b)

Figure 16: continued

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[2] https://www.birdair.com/technology/tensile-architecture/tensile-durability/, accessed 14 June 2023.